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LAKE LORAMIE, AUGLAIZE AND SHELBY COUNTIES

Pacific Northwest Environmental
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U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

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REPORT
ON
LAKE LORAMIE
AUGLAIZE AND SHELBY COUNTIES
OHIO
EPA REGION V
WORKING PAPER No. 405

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WITH THE COOPERATION OF THE
OHIO ENVIRONMENTAL PROTECTION AGENCY
AND THE
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JUNE, 1975

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Ohio Environmental Protection Agency for professional involvement, to the Ohio National Guard for conducting the tributary sampling phase of the Survey, and to those Ohio wastewater treatment plant operators who provided effluent samples and flow data.

Ned Williams, Director, and Tom Birch, Ken Carr, Larry Dietrick, Ron Havlice, Larry Korecko, Rod Mehlhop, Terry Wheeler, and John Youger, Ohio Environmental Protection Agency, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

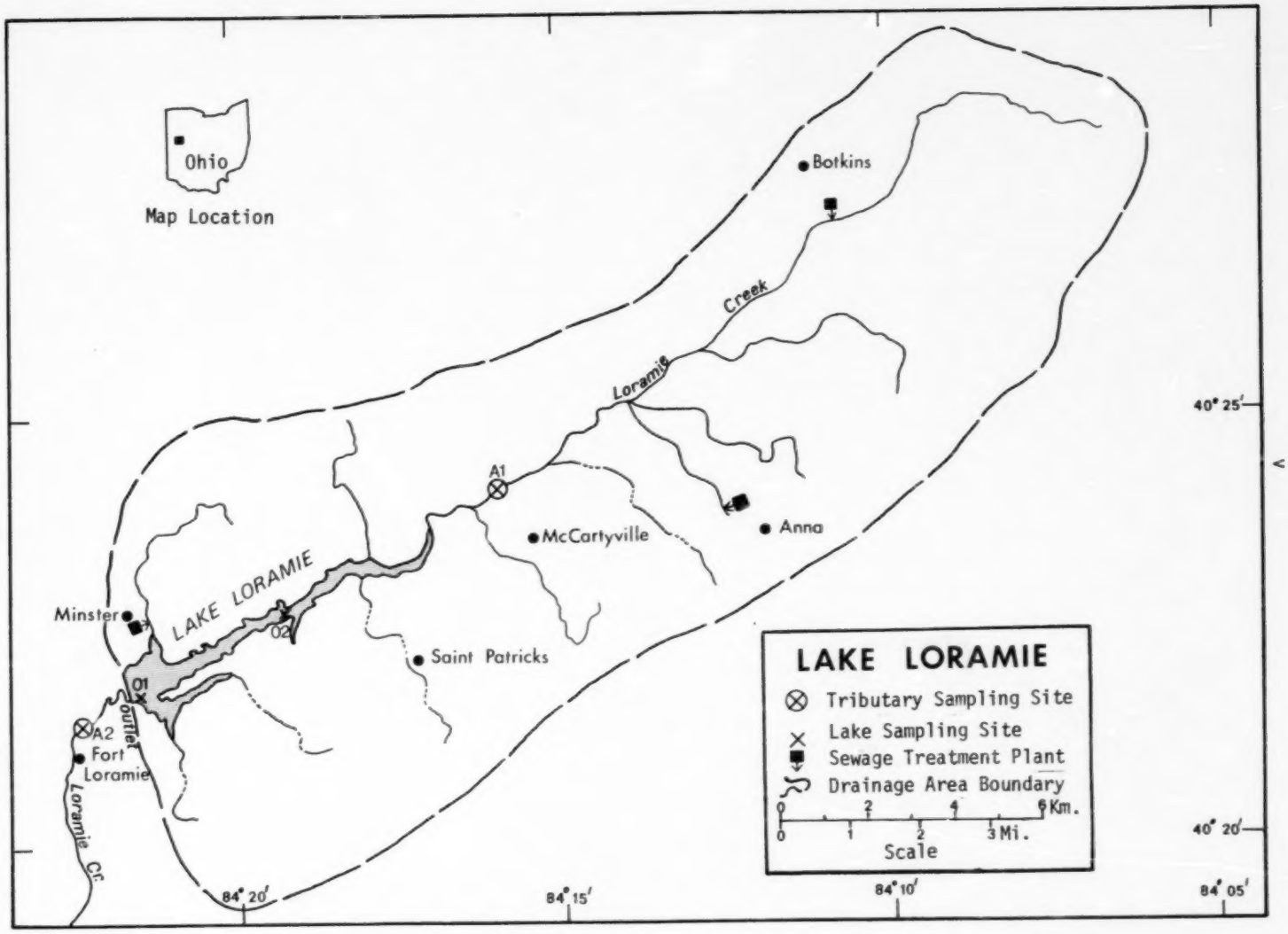
Major General Dana L. Stewart, then the Adjutant General of Ohio, and Project Officer Lt. Colonel Robert C. Timmons, who directed the volunteer efforts of the Ohio National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF OHIO

LAKE NAME	COUNTY
Atwood	Carroll, Tuscarawas
Beach City	Stark, Tuscarawas
Berlin	Mahoning, Portage, Stark
Buckeye	Fairfield, Licking, Perry
Charles Mill	Ashland, Richland
Deer Creek	Fayette, Pickaway
Delaware	Delaware
Dillon	Muskingum
Grand Lake of St. Marys	Auglaize, Mercer
Grant	Brown
Holiday	Huron
Hoover	Delaware, Franklin
Indian	Logan
Loramie	Auglaize, Shelby
Mosquito Creek	Trumbull
O'Shaughnessy	Delaware
Pymatuning	Ashtabula, OH; Crawford, PA
Pleasant Hill	Ashland, Richland
Rocky Fork	Highland
Shawnee	Greene
Tappan	Harrison


Ohio
Map Location
Botkins
Loramie Creek
A1
McCartyville
Anna
LAKE LORAMIE
Minster
02
Saint Patricks
01
Outlet
A2
Fort Loramie
Loramie Cr.
84° 20'
84° 15'
84° 10'
84° 05'
40° 25'
40° 20'
LAKE LORAMIE
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Plant
Drainage Area Boundary
0 2 4 6 Km.
0 1 2 3 Mi.
Scale

LAKE LORAMIE

STORET NO. 3917

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Lake Loramie is eutrophic. It ranked nineteenth in overall trophic quality when the 20 Ohio lakes sampled in 1973 were compared using a combination of six parameters*. Eighteen of the lakes had less median total phosphorus, 12 had less and one had the same median dissolved orthophosphorus, 12 had less median inorganic nitrogen, 18 had less mean chlorophyll a, and all of the other lakes had greater mean Secchi disc transparency.

Survey limnologists did not observe any surface concentrations of algae but noted that higher aquatic plants were abundant in many areas of the lake.

Almost continuous dredging of the lake is required to maintain satisfactory depths (Ketelle and Uttormark, 1971).

B. Rate-Limiting Nutrient:

The algal assay results indicate Lake Loramie was phosphorus limited at the time the sample was collected (05/04/73). The lake data indicate phosphorus limitation in August as well but nitrogen limitation in October.

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* See Appendix A.

C. Nutrient Controllability:

1. Point sources--The phosphorus contribution of known point sources amounted to 36% of the total load impacting Lake Loramie during the sampling year. The Anna, Botkins, and Minster wastewater treatment plants contributed 6.7%, 9.0%, and 23.3% of the total phosphorus load to the lake, respectively. It is estimated that septic tanks near the lake contributed less than 1%.

The present phosphorus loading of 4.22 $g/m^2/yr$ is five times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 13). However, Vollenweider's model probably does not apply to water bodies with short hydraulic retention times, and the mean hydraulic retention time of Lake Loramie is only 29 days. In view of the questionable applicability of the model and because the lake is mostly phosphorus limited, all phosphorus inputs should be minimized to the greatest practicable extent to slow the aging of Lake Loramie.

2. Non-point sources--Nearly 64% of the total annual phosphorus input to Lake Loramie was contributed by non-point sources. Loramie Creek contributed 41.4%, and the ungaged tributaries were estimated to have contributed 21.9% of the total load.

The phosphorus export rate of Loramie Creek (49 $kg/km^2/yr$) is

somewhat high as compared to the two tributaries of nearby Indian Lake* (20 and 34 kg/km^2/yr). The higher rate may have resulted from underestimation of the Anna and Botkins point-source loads, or the electroplating firm at Anna may have contributed phosphorus directly to Clay Creek and thence to Loramie Creek (see page 10).

* Working Paper No. 404.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 3.18 kilometers^2.
2. Mean depth: 1.5 meters.
3. Maximum depth: >5.1 meters.
4. Volume: 4.770 x 10^6 m^3.
5. Mean hydraulic retention time: 29 days.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Loramie Creek	112.9	1.1
Minor tributaries & immediate drainage -	85.1	0.8
Totals	198.0	1.9

2. Outlet -

Loramie Creek	201.2**	1.9

C. Precipitation***:

1. Year of sampling: 114.7 centimeters.
2. Mean annual: 92.9 centimeters.

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† Table of metric conversions--Appendix B.
†† Youger, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976).
** Includes area of lake.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Lake Loramie was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two stations on the lake and from one or more depths at each station (see map, page v). During each visit, a single depth-integrated (near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depth sampled at station 1 was 1.2 meters; only near-surface samples were taken at station 2.

The lake sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR LORAMIE LAKE
STORET CODE 3917

PARAMETER	1ST SAMPLING (5/ 4/73) 2 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (8/ 1/73) 2 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (10/11/73) 2 SITES RANGE	MEAN	MEDIAN
TEMP (C)	11.0 - 13.6	12.7	13.6	24.4 - 24.5	24.4	24.4	19.5 - 20.0	19.7	19.6
DISS OXY (MG/L)	6.8 - 11.4	9.1	9.1	7.0 - 7.4	7.2	7.2	7.4 - 7.6	7.5	7.5
CNDCTVY (MCROMO)	395. - 495.	437.	420.	334. - 473.	404.	404.	312. - 351.	326.	314.
PH (STAND UNITS)	8.5 - 8.9	8.6	8.5	8.3 - 8.4	8.3	8.3	8.3 - 8.6	8.4	8.4
TOT ALK (MG/L)	142. - 167.	150.	142.	110. - 150.	130.	130.	131. - 145.	138.	138.
TOT P (MG/L)	0.180 - 0.195	0.187	0.185	0.202 - 0.207	0.204	0.204	0.160 - 0.176	0.168	0.168
ORTHO P (MG/L)	0.014 - 0.019	0.016	0.014	0.012 - 0.020	0.016	0.016	0.027 - 0.030	0.028	0.028
NO2+NO3 (MG/L)	1.750 - 2.270	1.940	1.800	1.180 - 1.220	1.200	1.200	0.050 - 0.050	0.050	0.050
AMMONIA (MG/L)	0.050 - 0.060	0.057	0.060	0.150 - 0.200	0.175	0.175	0.060 - 0.080	0.070	0.070
KJEL N (MG/L)	1.600 - 2.000	1.800	1.800	2.100 - 2.400	2.250	2.250	1.600 - 1.600	1.600	1.600
INORG N (MG/L)	1.810 - 2.320	1.997	1.860	1.370 - 1.380	1.375	1.375	0.110 - 0.130	0.120	0.120
TOTAL N (MG/L)	3.600 - 3.870	3.740	3.750	3.280 - 3.620	3.450	3.450	1.650 - 1.650	1.650	1.650
CHLRPYL A (UG/L)	50.6 - 249.3	149.9	149.9	102.7 - 104.2	103.4	103.4	46.7 - 71.1	58.9	58.9
SECCHI (METERS)	0.1 - 0.2	0.1	0.1	0.2 - 0.2	0.2	0.2	0.2 - 0.2	0.2	0.2

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
05/04/73	1. *Melosira sp.*	21,531
	2. *Chlorella (?) sp.*	8,312
	3. *Stephanodiscus sp.*	6,152
	4. *Oscillatoria sp.*	4,450
	5. Flagellates	2,225
	Other genera	6,348
	Total	49,018
08/01/73	1. *Stephanodiscus sp.*	14,576
	2. Flagellates	10,380
	3. *Cryptomonas sp.*	3,092
	4. *Melosira sp.*	1,619
	5. *Pteromonas sp.*	1,178
	Other genera	7,435
	Total	38,280
10/11/73	1. *Merismopedia sp.*	11,829
	2. *Oscillatoria sp.*	11,063
	3. *Cyclotella sp.*	8,872
	4. *Dactylococcopsis sp.*	6,572
	5. *Synedra sp.*	5,258
	Other genera	23,004
	Total	66,599

2. Chlorophyll *a* -

Sampling Date	Station Number	Chlorophyll *a* (µg/l)
05/04/73	01	249.3
	02	50.6
08/01/73	01	102.7
	02	104.2
10/11/73	01	46.7
	02	71.1

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.040	1.968	15.5
0.050 P	0.090	1.968	31.5
0.050 P + 1.0 N	0.090	2.968	35.5
1.0 N	0.040	2.968	15.8

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Lake Loramie was very high at the time the sample was collected (05/04/73). The results also indicate the lake was phosphorus limited. Note that the addition of phosphorus alone produced a significant increase in yield, but the addition of only nitrogen produced a yield no greater than that of the control.

The lake data indicate phosphorus limitation in August as well (the mean inorganic nitrogen/orthophosphorus ratio was 86/1). However, nitrogen limitation is indicated in October (the mean N/P ratio was 4/1).

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Ohio National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff month of March when two samples were collected. Sampling was begun in May, 1973, and was completed in April, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Ohio District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the nutrient exports, in kg/km^2/year, at station D-1 of nearby Indian Lake and multiplying by the ZZ area in km^2.

The communities of Anna, Botkins, and Minster did not participate in the sampling program, and nutrient loads were estimated at 1.134 kg P and 3.401 kg N/capita/year.

* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal* -

Name	Pop. Served**	Treatment	Mean Flow† (m^3/d)	Receiving Water
Anna††	792	oxidation ditch + aer. pond	299.8	Clay Creek
Botkins	1,057	act. sludge	400.1	Loramie Creek
Minster	2,405	act. sludge	910.3	Unnamed Creek

2. Known industrial†† -

Name	Product	Treatment	Flow	Receiving Water
Electroplating Co., Anna	metal plating	none-wastes discharged directly to creek and to Anna municipal sewage treatment plant.	?	Clay Creek

* Anonymous, 1971.
** 1970 Census.
† Flow estimated at 0.3785 m^3/capita/day.
†† Youger, 1975.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Loramie Creek	5,550	41.4
b. Minor tributaries & immediate drainage (non-point load) -	2,935	21.9
c. Known municipal STP's -		
Anna	900	6.7
Botkins	1,200	9.0
Minster	2,725	20.3
d. Septic tanks* -	40	0.3
e. Known industrial -		
Electroplating Co.	?	-
f. Direct precipitation** -	55	0.4
Total	13,405	100.0

2. Outputs -

Lake outlet - Loramie Creek 22,195

3. Net annual P loss - 8,790 kg.

* Estimate based on 135 lakeshore dwellings and one park; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Loramie Creek	125,230	49.8
b. Minor tributaries & immediate drainage (non-point load) -	106,935	42.5
c. Known municipal STP's -		
Anna	2,695	1.1
Botkins	3,595	1.4
Minster	8,180	3.3
d. Septic tanks* -	1,475	0.6
e. Known industrial -		
Electroplating Co.	?	-
f. Direct precipitation** -	3,435	1.3
Total	251,545	100.0

2. Outputs -

Lake outlet - Loramie Creek 347,415

3. Net annual N loss - 95,870 kg.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
Loramie Creek	49	1,109

* Estimate based on 135 lakeshore dwellings and one park; see Working Paper No. 175.
** See Working Paper No. 175.

E. Yearly Loadings:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	4.22	loss*	79.1	loss*

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Lake Loramie:

"Dangerous" (eutrophic loading)	0.84
"Permissible" (oligotrophic loading)	0.42

* There was an apparent loss of nutrients during the sampling year. This may have been due to solubilization of previously sedimented nutrients during dredging (see page 1), recharge with nutrient-rich ground water, unknown and unsampled point sources discharging directly to the lake, or underestimation of the nutrient loads from the Minster sewage treatment plant which discharges to an unsampled tributary.

V. LITERATURE REVIEWED

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VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
3901	BEACH CITY RESERVOIR	0.122	1.990	489.000	10.867	11.600	0.015
3902	BUCKEYE LAKE	0.179	0.380	490.000	186.567	9.600	0.020
3905	CHARLES MILL RESERVOIR	0.127	0.465	482.555	67.144	15.000	0.011
3906	DEER CREEK RESERVOIR	0.098	2.980	470.125	9.887	13.900	0.036
3907	DELAWARE RESERVOIR	0.086	2.340	484.111	10.856	14.500	0.024
3908	DILLION RESERVOIR	0.163	1.590	481.250	27.400	14.300	0.037
3912	GRANT LAKE	0.113	0.570	486.333	40.533	12.200	0.019
3914	HOOVER RESERVOIR	0.040	1.640	462.750	13.017	14.800	0.008
3915	INDIAN LAKE	0.120	0.380	485.222	76.855	14.200	0.012
3917	LORAMIE LAKE	0.185	1.380	494.000	104.100	8.200	0.019
3921	MOSQUITO CREEK RESERVOIR	0.058	0.150	465.333	36.267	11.600	0.006
3924	PLEASANT HILL LAKE	0.036	0.455	456.833	22.850	14.700	0.010
3927	LAKE SAINT MARYS	0.148	0.200	484.167	79.150	8.200	0.014
3928	ATWOOD RESERVOIR	0.031	0.205	462.000	16.442	14.700	0.005
3929	BERLIN RESERVOIR	0.042	0.900	465.435	15.496	13.600	0.006
3930	HOLIDAY LAKE	0.125	0.575	465.333	55.350	15.000	0.034
3931	O'SHAUGNESSY RESERVOIR	0.208	3.070	479.333	5.522	14.900	0.159
3932	ROCKY FORK LAKE	0.067	0.790	473.000	38.022	15.000	0.010
3933	SHAWNEE LAKE	0.069	2.380	474.333	39.567	15.000	0.009
3934	TAPPAN LAKE	0.040	0.280	466.111	37.711	15.000	0.007

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
3901	BEACH CITY RESERVOIR	37 (7)	21 (4)	11 (2)	84 (16)	82 (15)	42 (8)	277
3902	BUCKEYE LAKE	11 (2)	76 (14)	5 (1)	0 (0)	89 (17)	26 (5)	207
3905	CHARLES MILL RESERVOIR	26 (5)	63 (12)	37 (7)	21 (4)	11 (0)	58 (11)	216
3906	DEER CREEK RESERVOIR	53 (10)	5 (1)	63 (12)	95 (18)	63 (12)	11 (2)	290
3907	DELAWARE RESERVOIR	58 (11)	16 (3)	32 (6)	89 (17)	47 (9)	21 (4)	263
3908	DILLION RESERVOIR	16 (3)	32 (6)	42 (8)	58 (11)	53 (10)	5 (1)	206
3912	GRANT LAKE	47 (9)	58 (11)	16 (3)	32 (6)	74 (14)	34 (6)	261
3914	HOOVER RESERVOIR	87 (16)	26 (5)	89 (17)	79 (15)	32 (6)	79 (15)	392
3915	INDIAN LAKE	42 (8)	76 (14)	21 (4)	16 (3)	58 (11)	53 (10)	266
3917	LORAMIE LAKE	5 (1)	37 (7)	0 (0)	5 (1)	97 (18)	34 (6)	178
3921	MOSQUITO CREEK RESERVOIR	74 (14)	100 (19)	82 (15)	53 (10)	82 (15)	92 (17)	483
3924	PLEASANT HILL LAKE	95 (18)	68 (13)	100 (19)	63 (12)	39 (7)	66 (12)	431
3927	LAKE SAINT MARYS	21 (4)	95 (18)	26 (5)	11 (2)	97 (18)	47 (9)	297
3928	ATWOOD RESERVOIR	100 (19)	89 (17)	95 (18)	68 (13)	39 (7)	100 (19)	491
3929	BERLIN RESERVOIR	79 (15)	42 (8)	74 (14)	74 (14)	68 (13)	92 (17)	429
3930	HOLIDAY LAKE	32 (6)	53 (10)	82 (15)	26 (5)	11 (0)	16 (3)	220
3931	O'SHAUGNESSY RESERVOIR	0 (0)	0 (0)	47 (9)	100 (19)	26 (5)	0 (0)	173
3932	ROCKY FORK LAKE	68 (13)	47 (9)	58 (11)	42 (8)	11 (0)	66 (12)	292
3933	SHAWNEE LAKE	63 (12)	11 (2)	53 (10)	37 (7)	11 (0)	74 (14)	249
3934	TAPPAN LAKE	87 (16)	84 (16)	68 (13)	47 (9)	11 (0)	84 (16)	381

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	3928	ATWOOD RESERVOIR	491
2	3921	MOSQUITO CREEK RESERVOIR	483
3	3924	PLEASANT HILL LAKE	431
4	3929	BERLIN RESERVOIR	429
5	3914	HOOVER RESERVOIR	392
6	3934	TAPPAN LAKE	381
7	3927	LAKE SAINT MARYS	297
8	3932	ROCKY FORK LAKE	292
9	3906	DEER CREEK RESERVOIR	290
10	3901	BEACH CITY RESERVOIR	277
11	3915	INDIAN LAKE	266
12	3907	DELAWARE RESERVOIR	263
13	3912	GRANT LAKE	261
14	3933	SHAWNEE LAKE	249
15	3930	HOLIDAY LAKE	220
16	3905	CHARLES MILL RESERVOIR	216
17	3902	BUCKEYE LAKE	207
18	3908	DILLION RESERVOIR	206
19	3917	LORAMIE LAKE	178
20	3931	O'SHAUGNESSY RESERVOIR	173

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

LAKE CODE 3917 LAKE LORAMIE

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 201.2

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
3917A1	112.9	1.61	1.90	2.75	2.21	1.30	0.76	0.48	0.24	0.18	0.22	0.45	0.93	1.08
3917A2	201.2	2.86	3.40	4.90	3.96	2.32	1.36	0.85	0.42	0.31	0.40	0.79	1.64	1.93
3917ZZ	88.3	1.25	1.50	2.15	1.76	1.02	0.59	0.37	0.18	0.14	0.17	0.34	0.71	0.84

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 201.2
SUM OF SUB-DRAINAGE AREAS = 201.2

TOTAL FLOW IN = 23.22
TOTAL FLOW OUT = 23.22

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3917A1	5	73	0.57	5	0.74				
	6	73	1.56	3	0.14				
	7	73	1.05	15	0.08				
	8	73	2.01	26	0.18				
	9	73	0.02	23	0.02				
	10	73	0.03	14	0.04				
	11	73	0.62	18	0.04				
	12	73	2.04	19	0.17				
	1	74	4.45	20	12.23				
	2	74	1.76	10	1.27	26	1.64		
	3	74	1.81	10	1.50	26	1.25		
	4	74	2.21	9	2.52				
3917A2	5	73	0.85	5	1.10				
	6	73	2.58	3	0.24				
	7	73	1.78	15	0.14				
	8	73	3.60	26	0.34				
	9	73	0.04	23	0.04				
	10	73	0.05	14	0.06				
	11	73	1.02	18	0.07				
	12	73	3.74	19	0.31				
	1	74	7.93	20	21.80				
	2	74	3.09	10	0.03	26	1.47		
	3	74	3.17	10	1.61	26	2.24		
	4	74	3.96	9	5.75				
3917ZZ	5	73	0.42						
	6	73	1.22						
	7	73	0.79						
	8	73	1.56						
	9	73	0.02						
	10	73	0.02						
	11	73	0.48						
	12	73	1.56						
	1	74	3.43						
	2	74	1.39						
	3	74	1.42						
	4	74	1.76						

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 75/01/27

391701
40 21 53.0 084 21 37.0
LORAMIE LAKE
39149 OHIO

11EPALES
3

2111202
0005 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/04	11	15 0000	13.6		4	420	8.90	142	0.060	1.800	1.800	0.014
	11	15 0003	13.6	11.4		395	8.50	142	0.060	2.000	1.750	0.014
73/08/01	10	20 0000	24.4	7.0	6	334	8.40	110	0.150	2.400	1.220	0.012
73/10/11	12	15 0000	19.6	7.6	8	314	8.30	131	0.080	1.600	0.050	0.030
	12	15 0004	19.5			312						

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/04	11	15 0000	0.185	249.3
	11	15 0003	0.195	
73/08/01	10	20 0000	0.202	102.7
73/10/11	12	15 0000	0.160	46.7

STORET RETRIEVAL DATE 75/01/27

391702
40 22 52.0 084 19 22.0
LORAMIE LAKE
39149 OHIO

11EPALES
3

2111202
0003 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/04	11 40	0000	11.0	6.8	6	495	8.50	167	0.050	1.600	2.270	0.019
73/08/01	10 40	0000	24.5	7.4	6	473	8.30	150	0.200	2.100	1.180	0.020
73/10/11	12 05	0000	20.0	7.4	6	351	8.60	145	0.060	1.600	0.050	0.027

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/04	11 40	0000	0.180	50.6
73/08/01	10 40	0000	0.207	104.2
73/10/11	12 05	0000	0.176	71.1

APPENDIX E

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 75/02/03

3917A1
40 24 30.0 084 16 00.0
LORAMIE CREEK
39091 7.5 NEW KNOXVILL
1/LORAMIE LAKE
ST HWY 29 BRDG 0.75 MI NW OF MCCARTYVILL
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/05/05	14 25		2.400	2.400	0.220	0.094	0.180
73/06/03	11 05		1.200	2.310	0.078	0.080	0.260
73/07/15	11 00		1.420	3.600	0.054	0.044	0.210
73/08/26	11 35		1.100	1.200	0.115	0.073	0.175
73/09/23	13 10		0.250	1.100	0.013	0.023	0.150
73/10/14	10 15		0.010K	2.000	0.023	0.131	0.375
73/11/18	11 20		1.060	1.300	0.160	0.160	0.330
74/01/20	14 30		3.500	0.500	0.084	0.080	0.200
74/02/10	14 30		2.940	1.900	0.230	0.085	0.165
74/03/10	11 00		2.940	1.100	0.165	0.110	0.260
74/03/26	08 50		2.520	1.100	0.170	0.110	0.200
74/04/09	19 00		2.900	1.200	0.120	0.090	0.220

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/12/02

3917A2
40 21 35.0 084 22 25.0
LORAMIE CREEK
39 7.5 FT LORAMIE
O/LORAMIE LAKE
ST HWY 66 BRDG 0.5 MI N OF FT LORAMIE
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/05/05	13 55		1.600	5.750	0.138	0.110	0.290		
73/06/03	10 40		0.620	2.520	0.315	0.380	0.590		
73/07/15	10 00		3.100	2.200	0.089	0.307	0.470		
73/08/26	11 10		0.390	1.900	0.130	0.105	0.250		
73/09/23	12 45		0.420	6.300	0.110	0.160	0.200		
73/10/14	10 30		0.280	4.350	0.200	0.180	0.250		
73/11/18	10 55		0.980	8.200	0.570	0.460	0.510		
73/12/19	13 00		2.900	2.300	0.490	0.276	0.375		
74/01/20	14 00		3.520	1.300	0.176	0.132	0.470		
74/02/10	14 00		2.760	3.900	1.100	0.094	0.140		
74/02/26	08 55		1.120	1.900	0.230	0.155	0.450		
74/03/10	10 30		3.780	1.600	0.150	0.055	0.230		
74/03/26	08 35		2.640	2.300	0.115	0.085	0.180		
74/04/09	18 45		2.800	2.100	0.155	0.150	0.760		